CONSTELLATION-X SXT

UNIT**:** OAP2

DATE: December 8, 2002

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DOCUMENT: D:\cxm_sxt_assy\OAP2_FEA_Results_Dec_08_2002.doc

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DESCRIPTION: Finite Element Results from OAP2 Model Update, December 2002

Summary

We have analyzed the revised OAP2 configuration as supplied to us in late October, running five load cases with results as shown in Table 1:

Load Case	**HPD(50 Deg Aperture)**
1G On edge (baseline)	7.1
1G flat	17.6
1G Vertical, baseline support	1.1
Thermal soak, per degree C (Baseline support strut)	0.4

Table 1 – Baseline Performance

Thermal Sensitivities

The thermal sensitivity is much reduced from earlier work. This is due to a series of changes in the configuration, most of which have produced reductions in the thermal sensitivity. Table 2 presents sensitivity data for 15 different configurations in terms of HPD (over 50 degree aperture) ***per unit ppm strain***. Entries in the table are ranked in order of sensitivity, from most sensitive in row 1 to least sensitive in the bottom row. The top two entries (Cases 1 and 2) are from our December 2001 work. The configuration was glass only with either fixed (all six DOF zero) or pinned (3 translation DOF zero, rotations free) boundary conditions. Five equally spaced supports were placed at each end of the optic. In some cases supports were added in the middle of each edge. These two cases had very high sensitivity and were representative of the thermal sensitivities obtained last year from the glass-only configuration. The next seven cases in order

of sensitivity are all variations of glass-only configurations. Figure 1 illustrates the glass-only FEA model. Cases 3 and 4 have five supports at each end, but the support locations and optic azimuthal extent are different from cases 1 and 2. Cases 5 through 9 have six supports at each end and their sensitivity is lower than the cases with five supports

. The bottom six cases in terms of sensitivity are all OAP2 model cases with various configurations. In these cases we are modeling the OAP2 housing and optic support struts, which add flexibility to the system and somewhat relieve the constraint on the glass. We also have six attachment points at each end and, in one case, one on each edge. The glass itself is 54 degrees in angular extent. Case 10 has edge struts, which increases sensitivity (by a factor of 2) of the OAP2 vs. configurations without these struts. They have since been deleted from the OAP2 baseline design. Cases 11 and 12 were run with the "initial" OAP2 configuration, which had 3/16" walls and flat titanium strips holding the P and H housings together. The absence of an interferometer window ("hole") in case 11 and its presence in case 12 did not seem to make much difference in performance. Finally, the bottom three cases, Cases 13, 14 and 15, (lowest in thermal sensitivity) are for the latest GSFC OAP2 design configuration, obtained in early November. "T" sections connect the P and H housings. A flat reference mirror has been added to the P module. There is a wider edge around the hole at aft ends of each module and 3/8" walls are used, except for the radial sides, which are still 3/16". In Cases 13 and 14 rigid elements were used to model the support posts and cross-beam. In Case 14 the support struts were relieved (U section cut down into a flat blade) at both attachment ends to provide more flexibility and reduce thermal sensitivity. The sensitivity for Case 14 is reduced, but not significantly so (0.20 HPD per degree C vs. 0.27 for Case 13). Finally, the support posts and cross-beam were modeled as Titanium elements in Case 15, which gave the lowest sensitivity of the 15 cases.

In summary, analysis changes:

- Add non-rigid housing to FEA model

And design changes:

- Six end supports vs. five
- No edge support
- Ti housing
- Ti support posts and cross-beam

have led to a design with much reduced sensitivity to bulk temperature changes.

As a follow-on analysis we will consider gradient effects in conjunction with a thermal model.

Case #	Configuration Name	# Side Supports	# End Supports	Type Support	HPD per ppm	Comments
1	fit_disp_28	0	5	Pinned	4.25	glass only, Dec 2001 even configuration
2	fit_disp_47	1	5	Fixed	3.85	glass only, Dec 2001 even configuration
3	OAP2_fem8_5pts	1	5	Pinned	3.58	glass only, OAP2 Configuration, 5 Points per end
4	p_5pt	0	5	Pinned	3.42	glass only (check case)
5	p_6pt_rotated	0	6	Pinned	2.30	glass only (check case)
6	OAP2_fem8_fixed	1	6	Fixed	2.28	glass only, OAP2 Configuration
7	OAP2_fem8_pinned	1	6	Pinned	2.16	glass only, OAP2 Configuration
8	OAP2_fem8_pinned_even	1	6	Pinned(even spacing)	1.96	glass only, OAP2 Configuration
9	p_6pt	0	6	Pinned(even)	1.88	glass only (check case)
10	OAP2_fem2	1	6	Attached to struts	1.38	OAP2 initial, 3/16 Ti walls, With Hole
11	OAP2_fem3	0	6	Attached to struts	0.59	OAP2 initial, 3/16 Ti walls, no edge-struts, No hole
12	OAP2_fem2a	0	6	Attached to struts	0.58	OAP2 initial, 3/16 Ti walls, no edge-struts, with hole
13	OAP2_fem9	0	6	Attached to struts	0.17	November Baseline, with hole, no edge struts, rigid support posts and beam
14	OAP2_fem10	0	6	Attached to struts	0.12	Nov baseline, flexured struts with hole, no edge struts
15	OAP2_fem11	0	6	Attached to struts	0.18	Nov baseline, flexured struts with hole, no edge struts, Ti support posts and beam

Table 2 – Thermal Sensitivity per Unit ppm Strain (50 deg Aperture)

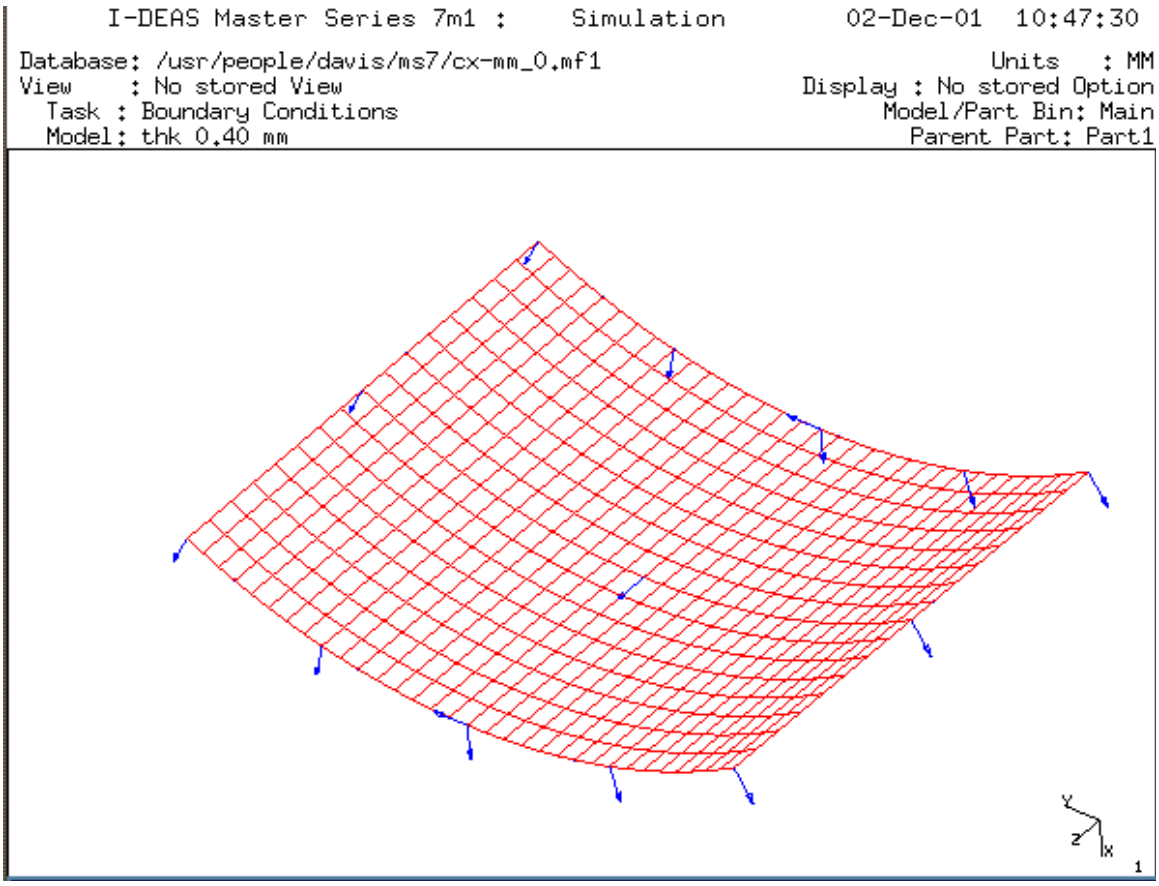

Figure 1 – Glass-Only FEA Models

Assembly Support Condition

The FEA model of the assembly configuration is shown in Figure 2 and a view of the housing-to-housing assembly process and GSE is shown in Figure 3. The assembly plan is as follows:

1. Install P and H housings with optics on two sets of three point supports
2. Rough-align optics in P and H housings
3. Install "T" beams between P and H housings using assembly GSE shown in Figure 3.
4. Perform final alignment of optics and bond to P and H housings

Given this assembly sequence, the strain which is present during final optic bonding will be locked into the optics and represents the "assembly strain" portion of the error budget (3 arc-second allocation). Our FEA results indicate about a 1.1 arc-second HPD contribution in this configuration, a result within our allocation.

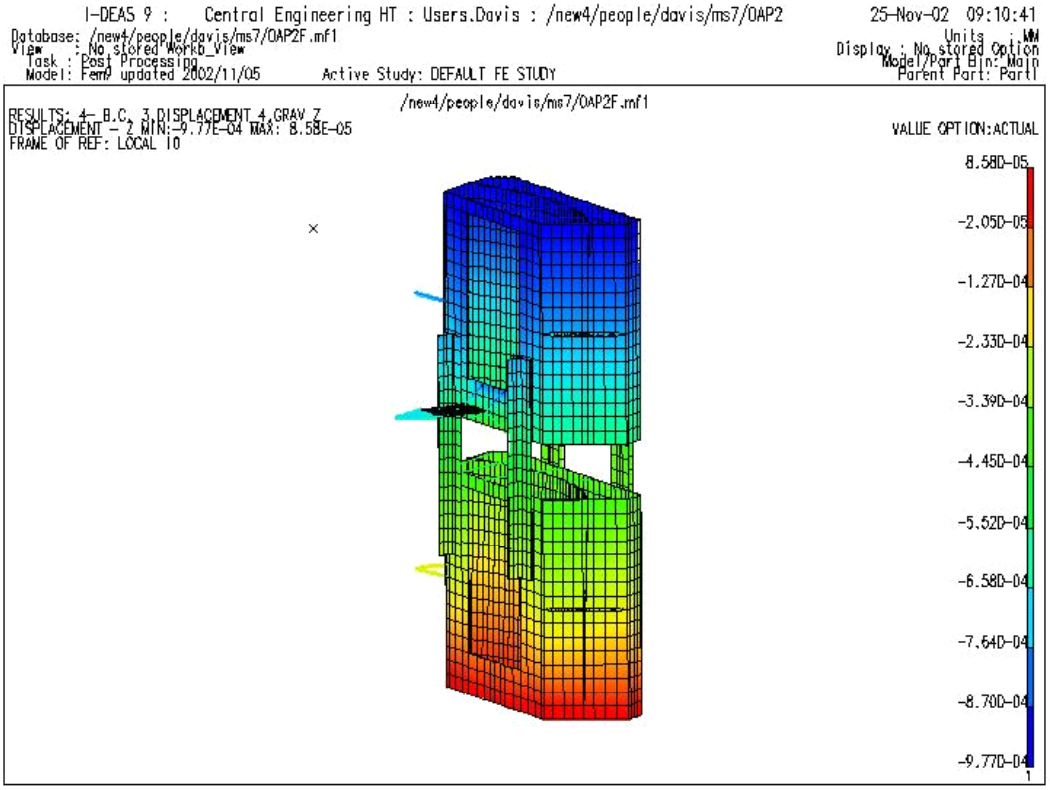

Figure 2 – FEA Model, Assembly Configuration

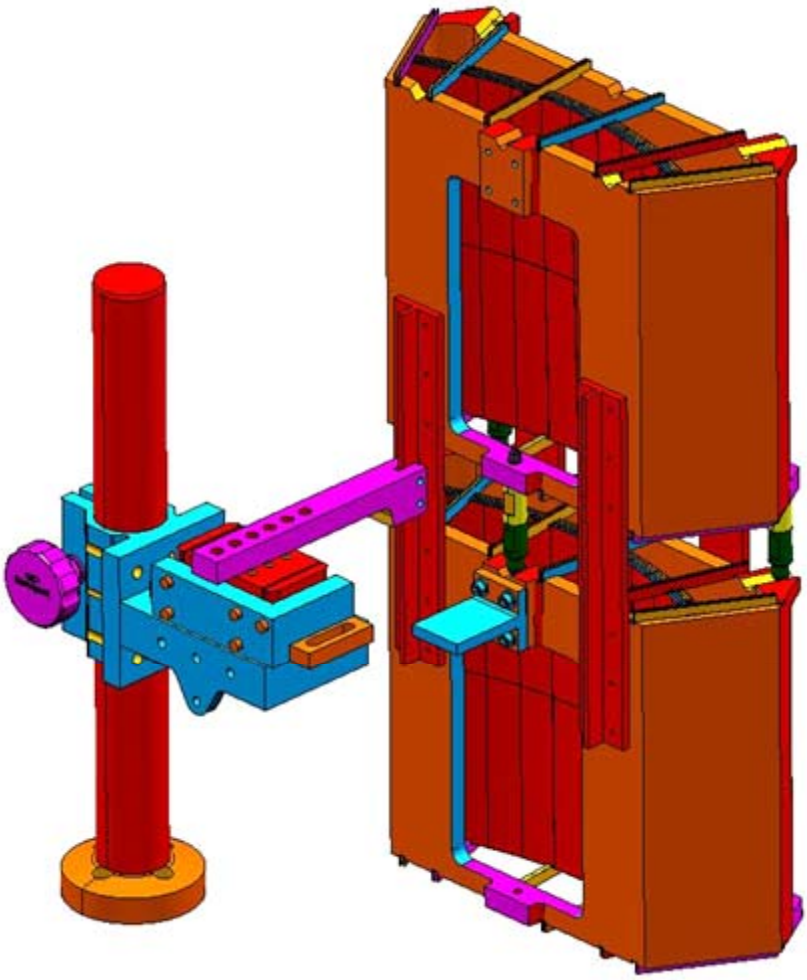

Figure 3 – Assembly Process and GSE

X-Ray Test Support Condition

Two configurations for the x-ray test have been considered, the "edge" and the "flat" configurations, as shown in Figure 4.

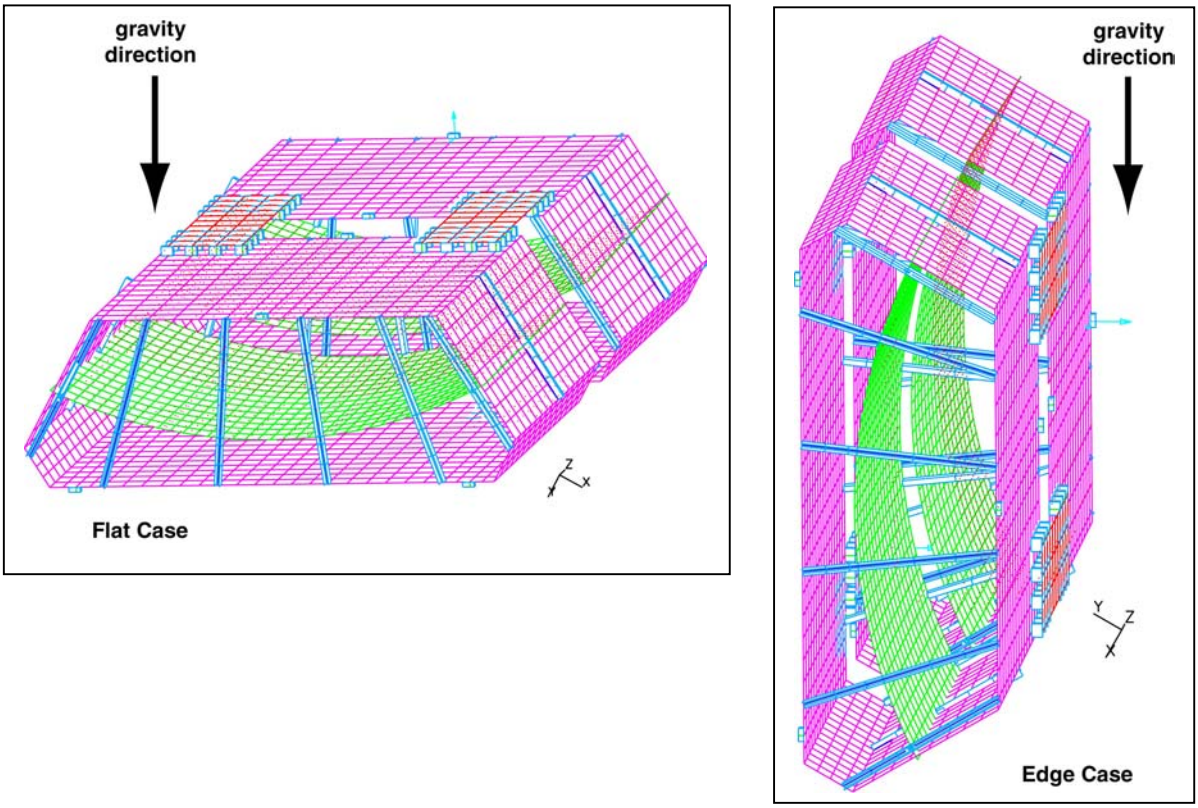

Figure 4 – X-Ray Test Configurations

Our analyses have led to the choice of the "edge" x-ray test configuration. Figures 5 and 6 show performance results (HPD vs. aperture size for various configurations) for the two configurations. For both configurations, the incorporation of an "edge" support (bond mirror to housing at axial mid-point of each mirror, both sides) improves x-ray test performance. However, this added support also has a negative impact on thermal sensitivity. If we choose not to have an edge support, then the "edge" x-ray test configuration is clearly better than the "flat", (see Table 1).

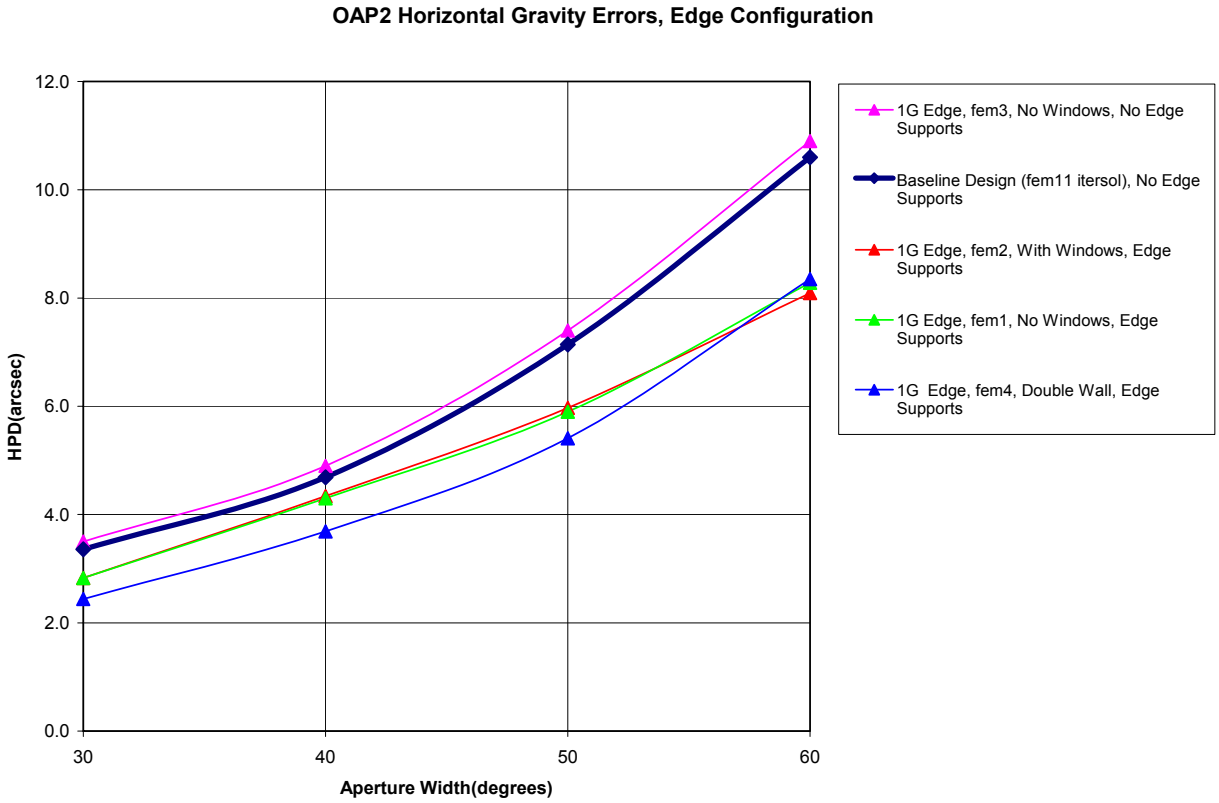

Figure 5 – Horizontal Gravity Results, Edge Configuration

During x-ray testing the OAP2 will be supported on four posts as shown in Figure 7. The two posts on the H housing will be connected with a cross-beam. Ball and V-groove interfaces will be attached to the two P support posts and to the center of the cross-beam on the H housing. The directions of the three grooves meet in a single point beneath the mirror node, as shown in Figure 8, making a kinematic interface between the OAP2 and support plate. The support posts will be bonded to the OAP2 housings after alignment is complete and the OAP1 housings removed. The OAP2 will be in the vertical assembly condition during bonding of the support posts. The same GSE as used during T beam installation will be used to hold the support posts during bonding.

The 1G structural distortion contribution to HPD in the on-edge x-ray test is 7.1 arc-seconds at the nominal 50 degree aperture. This may be reduced to under 4 arc-seconds by use of a 30 degree aperture. The distortions of the housing in the x-ray test mount are shown in Figure 9.

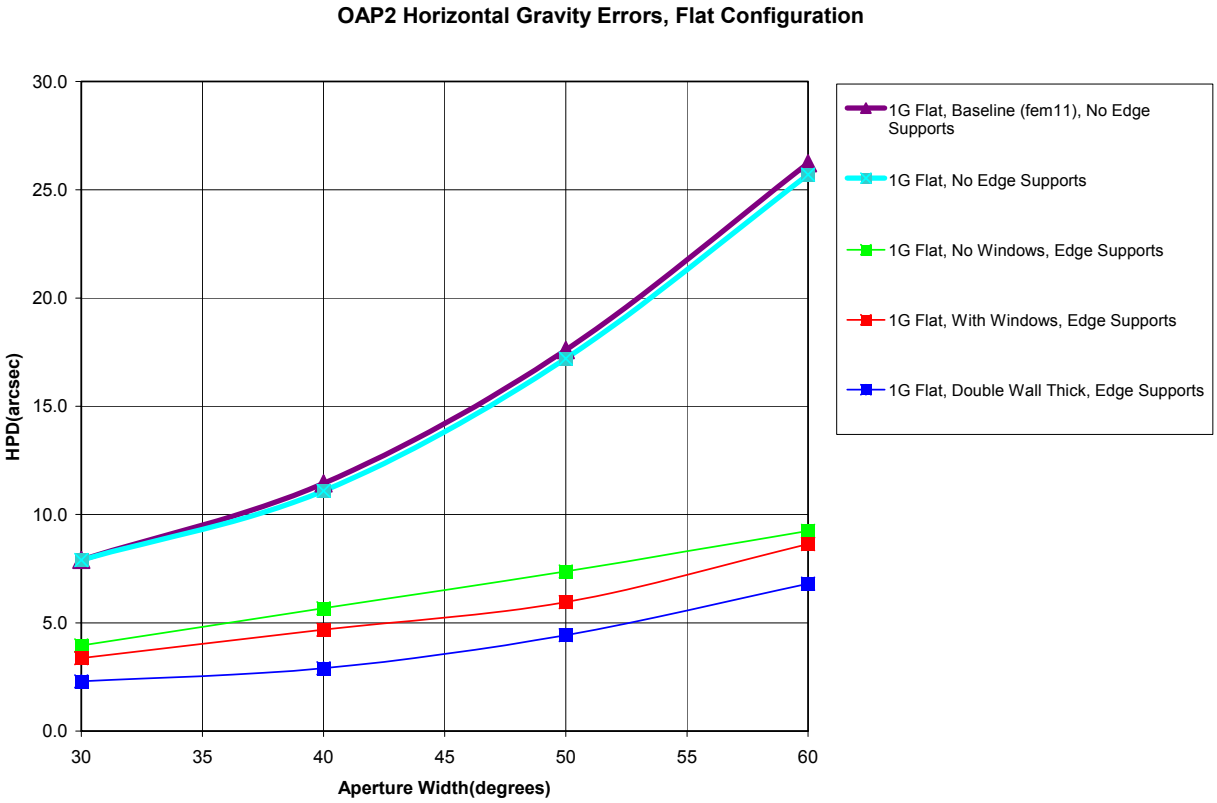

Figure 6 – Horizontal Gravity Results, Flat Configuration

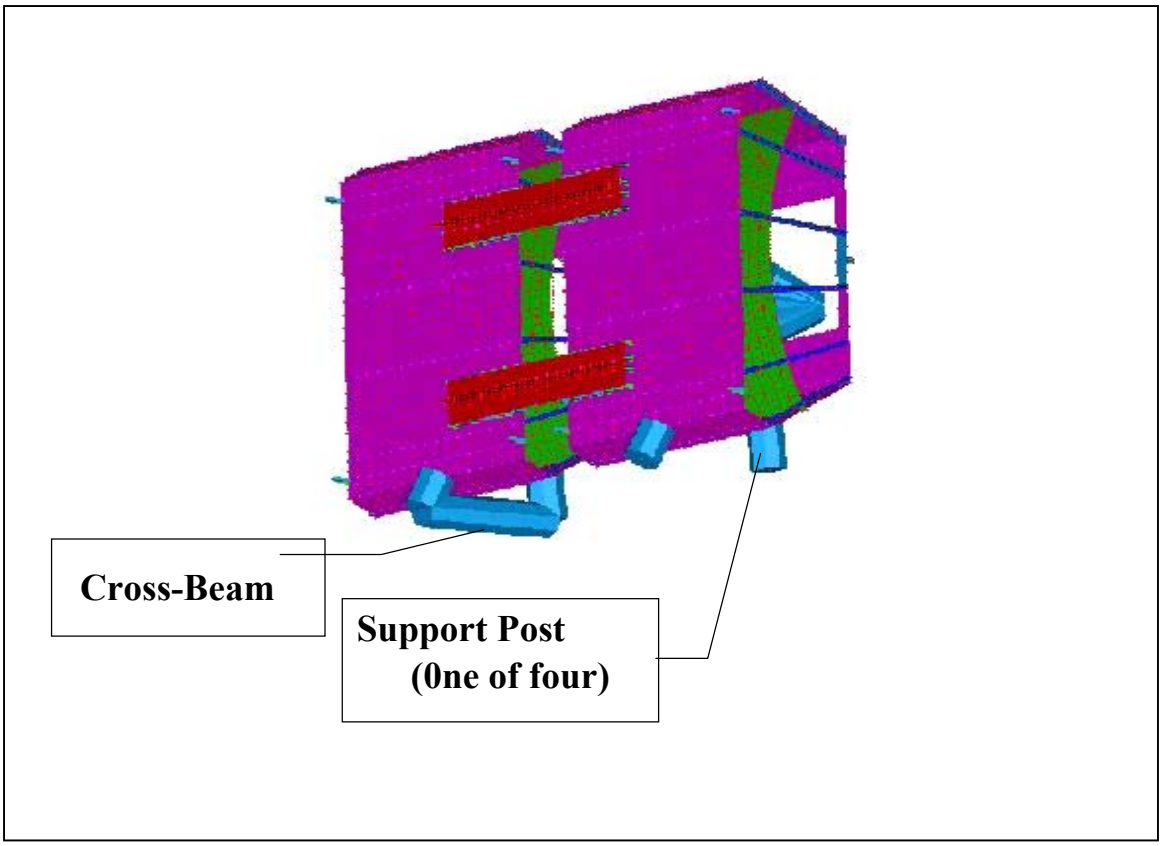

Figure 7 – X-Ray Test Mount

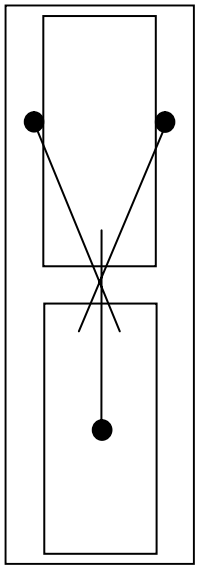

Figure 8
3 Point Mount

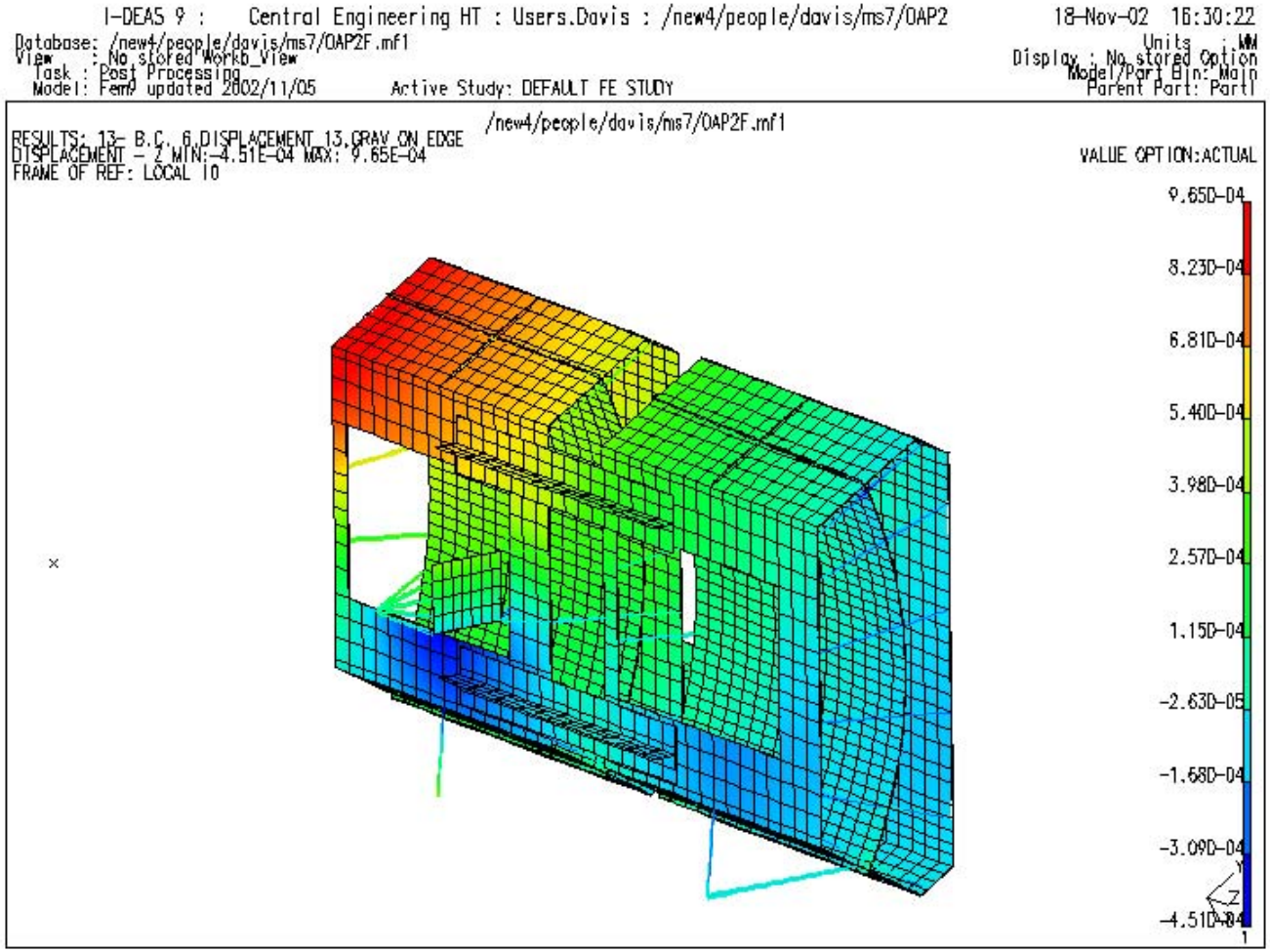

Figure 9 – Housing Distortion in X-Ray Test Mount

Supplementary Data

- Table A1 – FEA Model Summary
- Figure A1 – Thermal Sensitivity Plot

model file	model	Hole?	Edge Struts?	description	Results file
OAP2E	fem1 (baseline model)	No	Yes	3/16 walls, no hole, flat strips tying P-H together, mid-side struts	fit_OAP2_400
OAP2E	fem2 (with hole)	Yes	Yes	same as fem1 but added 175mm x 92.6mm windows	fit_OAP2_w_hole
OAP2E	fem2a (with hole/no edge struts)	Yes	Yes	same as fem1 but added 175mm x 92.6mm windows	fit_OAP2_fem2a
OAP2E	fem3 (no edge struts)	No	No	same as fem1 but edge struts removed	fit_OAP2_no-edge-struts
OAP2E	fem4 (3/8 thk wall - no hole)	No	Yes	3/8 walls, no hole, flat strips tying P-H together, mid-side struts	fit_OAP2_…_fem4
OAP2E	fem5 very stiff	No	Yes	same as fem4 but Titanium stiffness x 1e6	fit_OAP2_rigid_Ti
OAP2E	fem6 very stiff no edge restr	No	No	same as fem4 but Titanium stiffness x 1e6 and no mid side struts	fit_OAP2_rigid_Ti_…no-edge-struts
OAP2E	fem7 stiff zero cte no edge struts	No	No	same as fem6 but zero cte titanium	fit_OAP2_rigid_Ti_zero-cte
OAP2E	fem8 glass only	N/A	N/A	glass only	fit_OAP2_glass-only
OAP2F	fem9 updated 2002/11/05	Yes	No	modified to latest GSFC model, "T" sections connecting P-H, added flat reference mirror to P module, wider edge around hole at aft ends of each module, 3/8 walls except radial sides, added beam elements for on-edge support condition	fit_fem9
OAP2F	fem10 flexured struts	Yes	No	same as fem9 except for flexured struts at front of P and back of H 0.125" wide x 0.0625" thick	fit_fem10
OAP2F	fem10 titanium posts and cross-beams	Yes	No	same as fem9 except support posts and cross-beam are titanium instead of rigid.	fit_fem11

Table A1 – FEA Model Summary

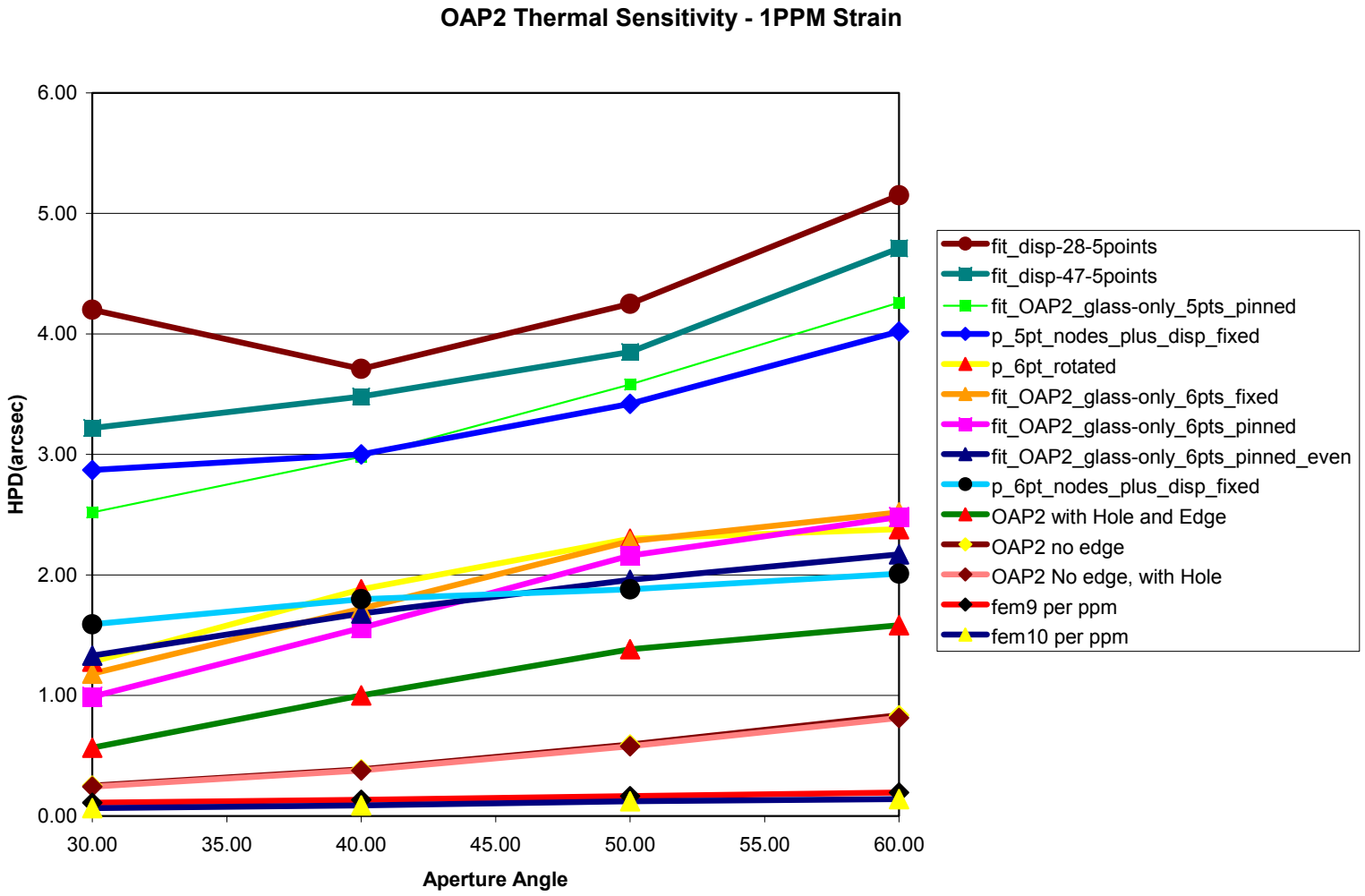

Figure A1 – Thermal Sensitivity Plot